



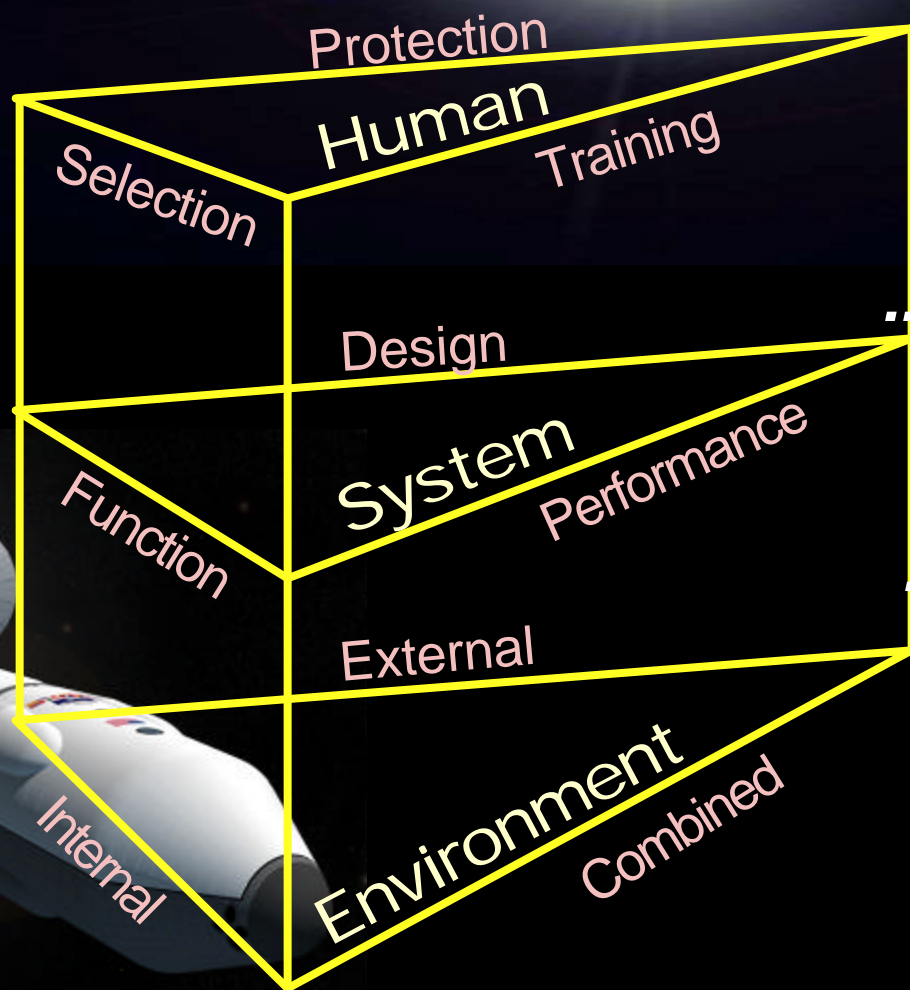
NASA Clinical Objectives for Long Duration Space Flight

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NASA Mission Success



*Designers must facilitate **Human** performance...*

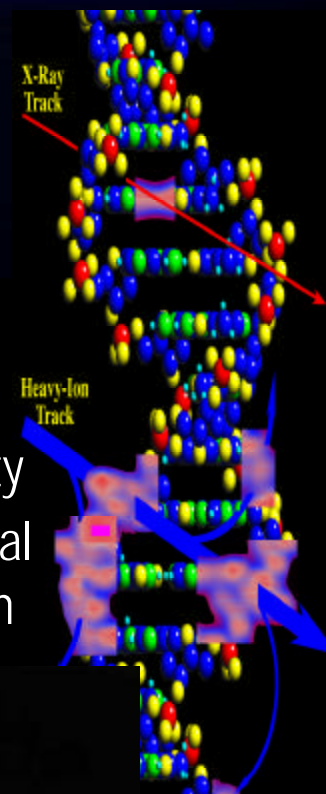
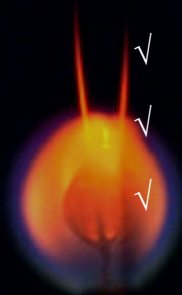
*...by creating a **System** that responds effectively...*

*...to the challenges of the space flight **Environment**.*



High Risk/ Extreme Environment

- ▶ Ground health emergencies may occur in flight
- ▶ Lack of secondary and tertiary care
- ▶ Space flight risks
 - √ Adaptation to microgravity
 - √ Psychosocial issues
 - √ Decompression sickness
 - √ Spacecraft decompression
 - √ Fire
 - √ Temperature extremes, radiation, toxicology
 - √ In flight medical problems
- ▶ Long duration flight
 - √ Career hazards
 - √ Chronic diseases
- ▶ Health risks on return to Earth
 - √ Emergency egress liability
 - √ Re-adaptation to terrestrial environment/rehabilitation





Physiological Response to Spaceflight

- Adaptive
- Pathological



Neurosensory & Neuromotor

Cardiovascular/
Pulmonary

Endocrine

Musculoskeletal



parallels with aging...





NASA Space Medical Operations

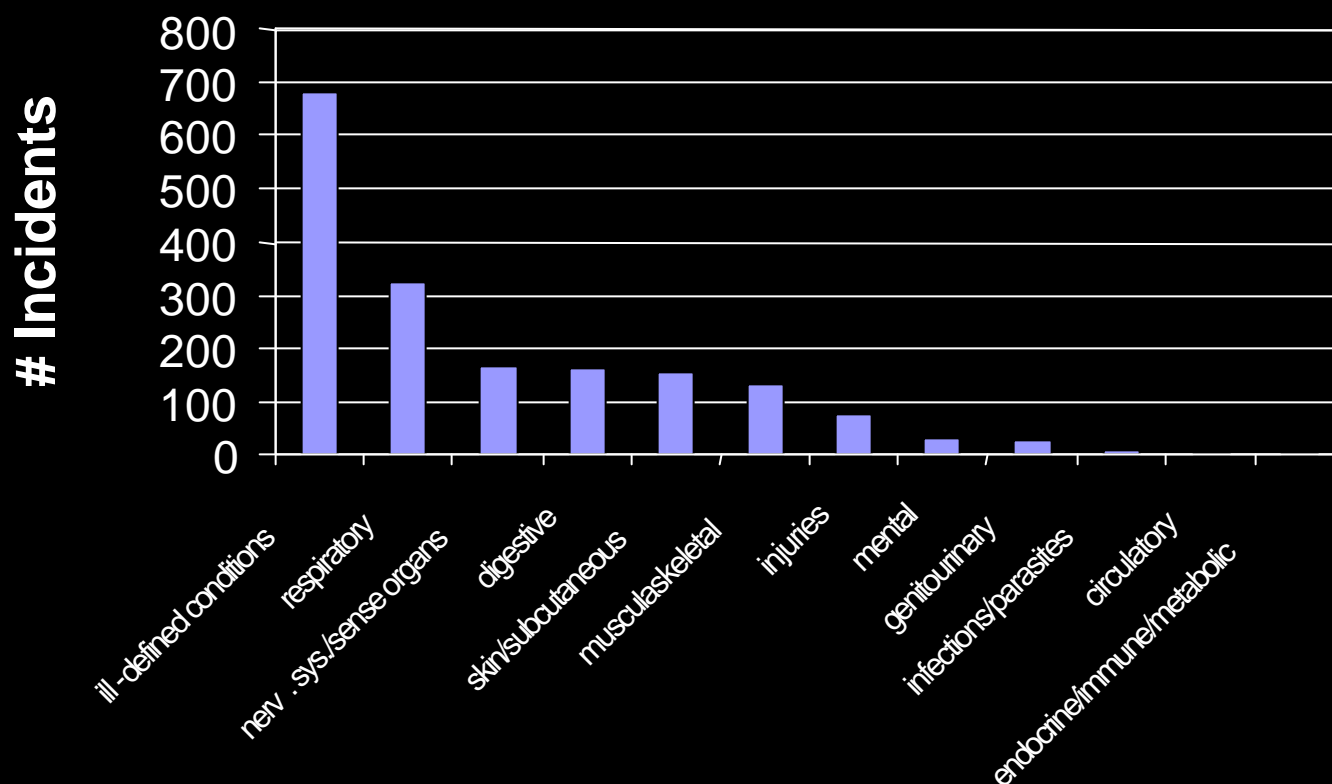
- ▶ No U.S. space mission shortened or aborted due to medical problems
 - √ Reflects excellent preventive care/ astronaut selection
- ▶ Several Russian missions compromised by medical incidents
- ▶ NASA has developed limited diagnostic and therapeutic capability for use in space
 - √ Medical kit
 - √ Crew medical officer training, flight surgeon training
 - √ Defibrillator-advanced life support
 - √ Telemedicine
- ▶ Inadequate countermeasures capability





In Flight Medical Events STS-1 through STS-89

- ▶ 498 of 508 crewmembers reported medical event or symptom (excludes space motion sickness)
- ▶ 1777 separate events reported
- ▶ 1538 by men, 239 by women
- ▶ 77 events due to injury, including 7 fatalities





NASA Health Criteria

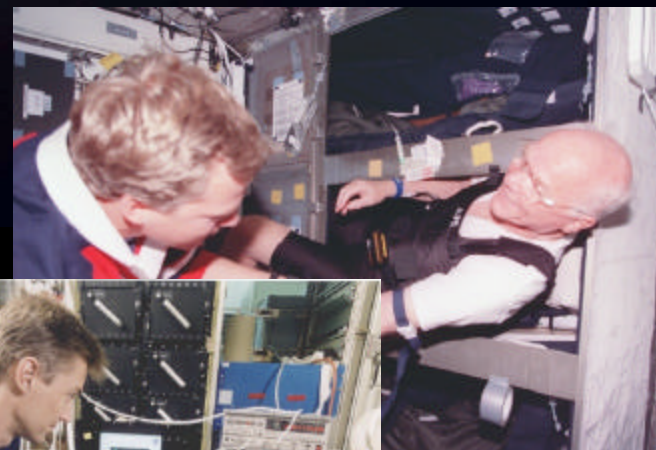
- ▶ Maintain health and well-being before, during, and after mission
- ▶ Ensure rapid re-adaptation to gravitational forces





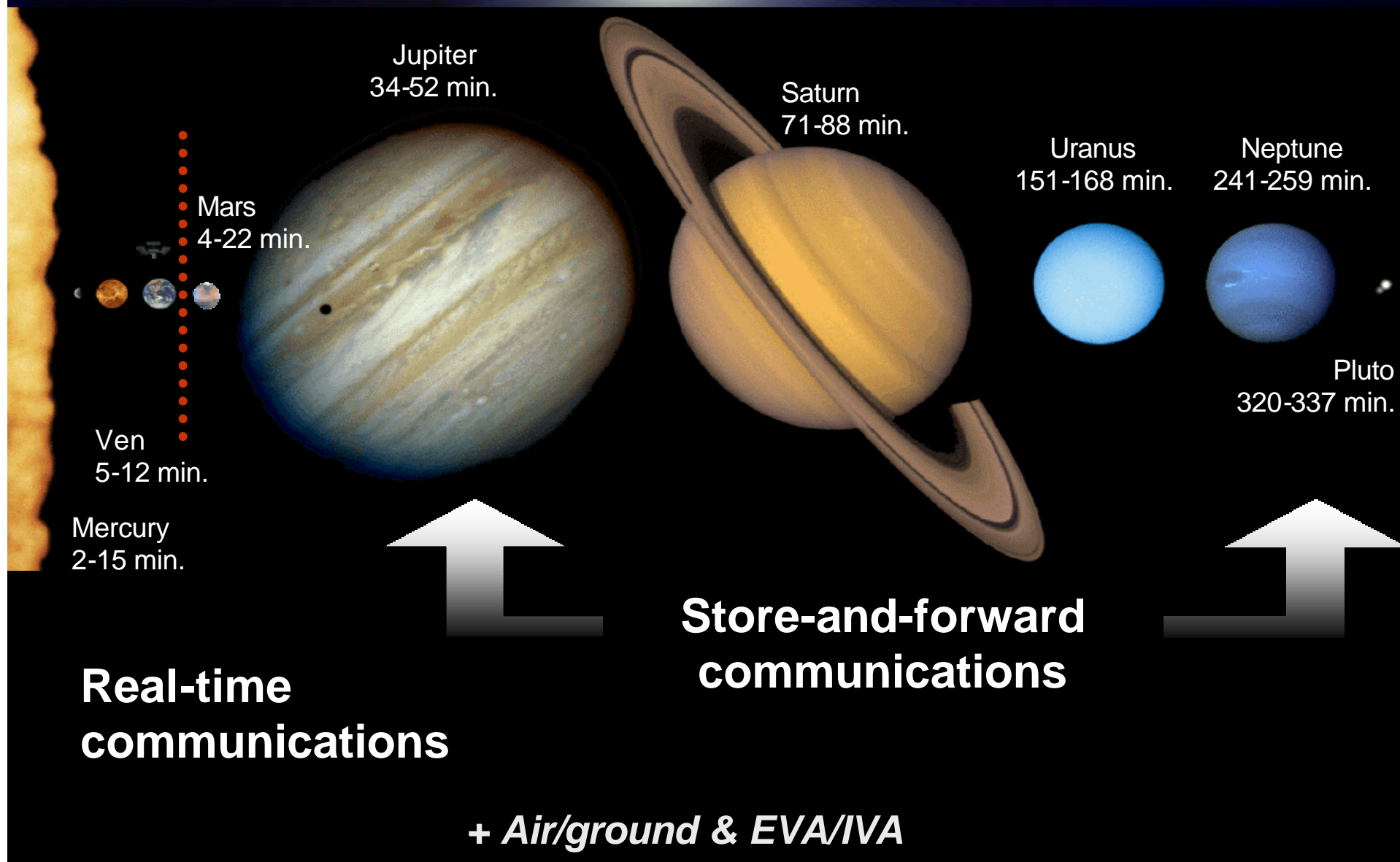
NASA Medical Care Criteria

- ▶ Ability to treat crew members and return them to duty
- ▶ Minimize impact on remainder of crew
- ▶ Provide for stabilization and evacuation (in LEO)
- ▶ Provide for crew safety
- ▶ Provide for remote consultation
- ▶ Provide autonomous care



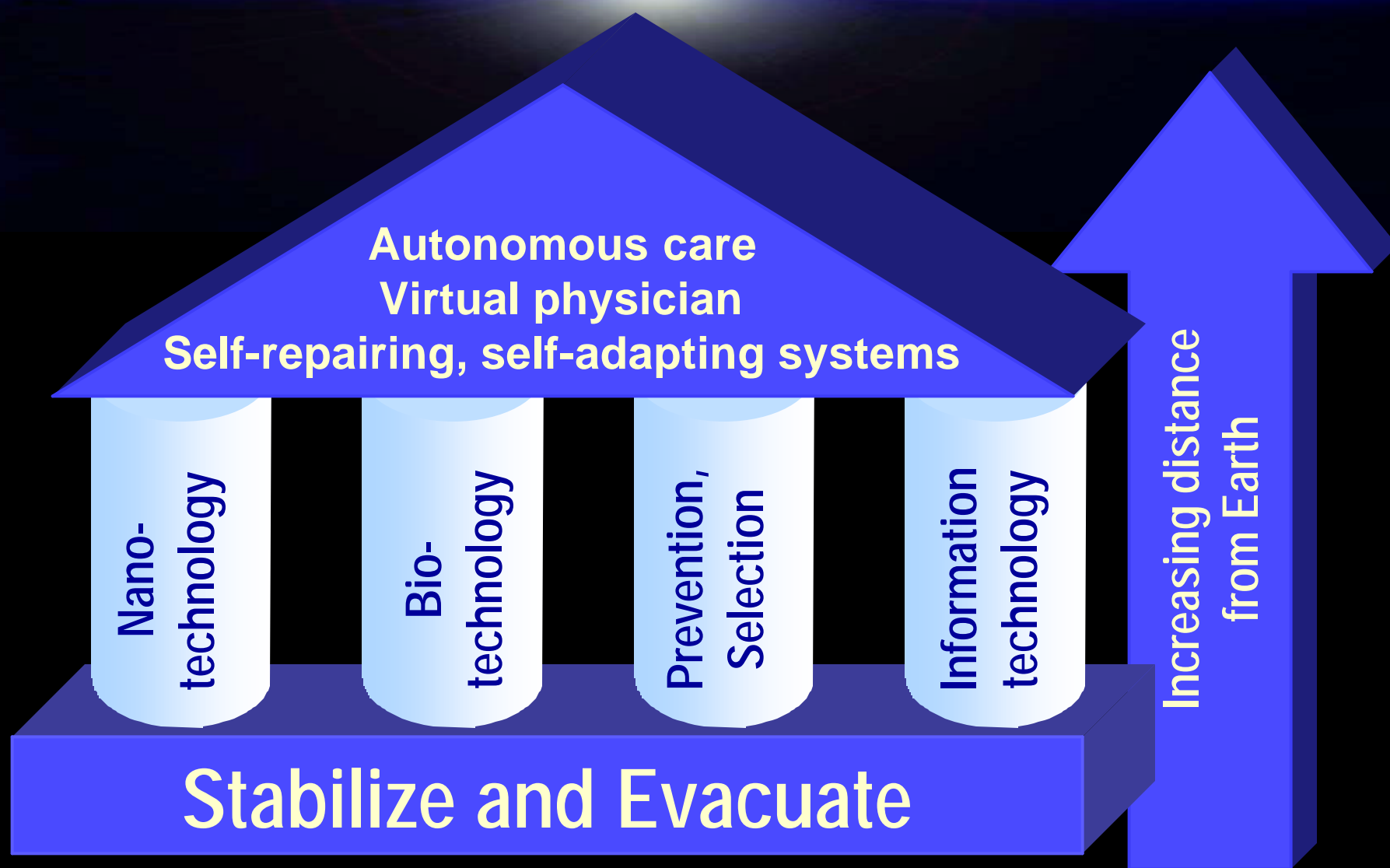


Communications Challenge: Time and Space





Health Care Beyond LEO

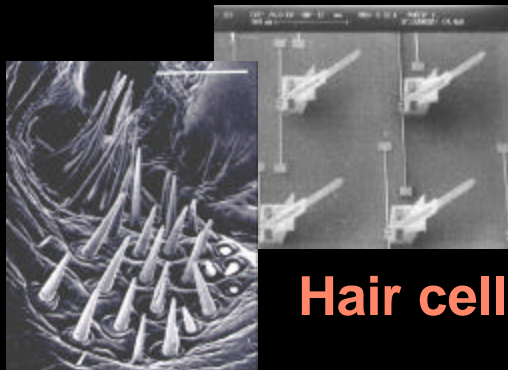




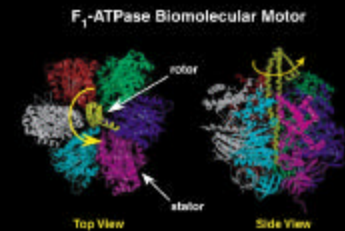
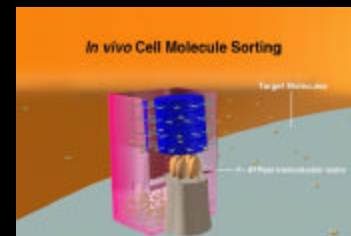
Future of Health Care in the U.S. Space Program

From telecare to autonomy...

- ▶ Adaptive automation
- ▶ Multipurpose tactile interface
- ▶ Biosensors for environmental and physiologic monitoring
- ▶ Genetic profiling
- ▶ Genetic diagnosis
- ▶ Genetic vaccines
- ▶ Tissue engineering
- ▶ Biologically-inspired robots
- ▶ Biotech based immunotherapy
- ▶ Functionally-adaptive biomimetics
- ▶ Nanomachines (self assembly)
 - √ Cell herding, genetic surgery
- ▶ Biologically based nanocomputers
 - √ Artificial intelligence
- ▶ Smart/haptic systems
- ▶ Virtual physician



Hair cell sensors



Biomotors

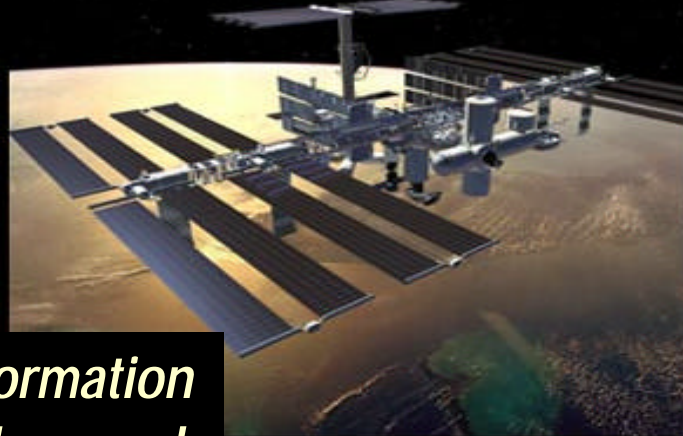


Conclusion

1969



2000



2010+

The synergy between information technology, nanotechnology and biotechnology/biologically inspired technology will allow NASA to send astronauts on safe, productive long-term exploration missions.

